

Revised description of *Simulium* (*Simulium*) *forcipatum* Delfinado, and description of three new related species from Luzon Island, Philippines (Diptera: Simuliidae)

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Abstract: The female, pupa and mature larva of *Simulium* (*Simulium*) *forcipatum* Delfinado are described for the first time based on the samples collected from Ifugao and Mountain Provinces, Luzon Island, the Philippines. Three species closely related to *S. (S.) forcipatum*, which were found from the same and/or nearby rivers or streams, are described as new species. All these four species are distinctive among the *melanopus* species-group of the subgenus *Simulium* (*Simulium*) Latreille s. str. in having a wall-pocket-shaped cocoon in place of the shoe-shaped or boot-shaped cocoon as well as the male ventral plate with teeth on its posteroventral surface in two vertical rows lying very close to each other.

Key words: *Simulium*, black fly, Simuliidae, Luzon, Philippines, description

Recently a few surveys were carried out on the immature stages of black flies (Diptera: Simuliidae) in northern parts of Luzon Island, the Philippines. Among the new species found in these surveys, seven were already described (Takaoka, 2000, 2005, 2006a, b).

In this paper, three more new species are described on the basis of the reared adults, pupae and/or mature larvae. In addition, the female, pupa and mature larva of *Simulium* (*Simulium*) *forcipatum* Delfinado are described for the first time. All these new species and *S. (S.) forcipatum* are morphologically very similar to one another and are assigned to the *melanopus* species-group of the subgenus *Simulium* (*Simulium*) Latreille s. str., defined by Takaoka (1983) and redefined by Takaoka (2003). They are distinctive within this species-group by having a wall-pocket-shaped cocoon in place of a shoe-shaped or boot-shaped cocoon as well as the male ventral plate with teeth on its post-

eroventral surface in two vertical rows lying very close to each other.

The terms for morphological features used here follow those of Takaoka (2003). Holotype and paratype specimens of the new species are deposited at the Department of Infectious Disease Control, Faculty of Medicine, Oita University, Oita, Japan.

Simulium (*Simulium*) *forcipatum* Delfinado

Simulium (*Simulium*) *forcipatum* Delfinado, 1969: 202 (male); Takaoka, 1983: 134–135 (male).

DESCRIPTION (based on specimens from Magkang). **Female.** Body length 3.0 mm (3.3 mm in 3 females from Bayyo). **Head.** Narrower than width of thorax. Frons brownish-black, shiny, with several dark stout hairs along lateral margins; frontal ratio 1.1–1.2 : 1.0 : 1.1–1.3 (1.26 : 1.00 : 1.32 in 1 female from Bayyo); frons-head ratio 1.0 : 4.3–4.5 (1.0 : 4.2 in 1 female from

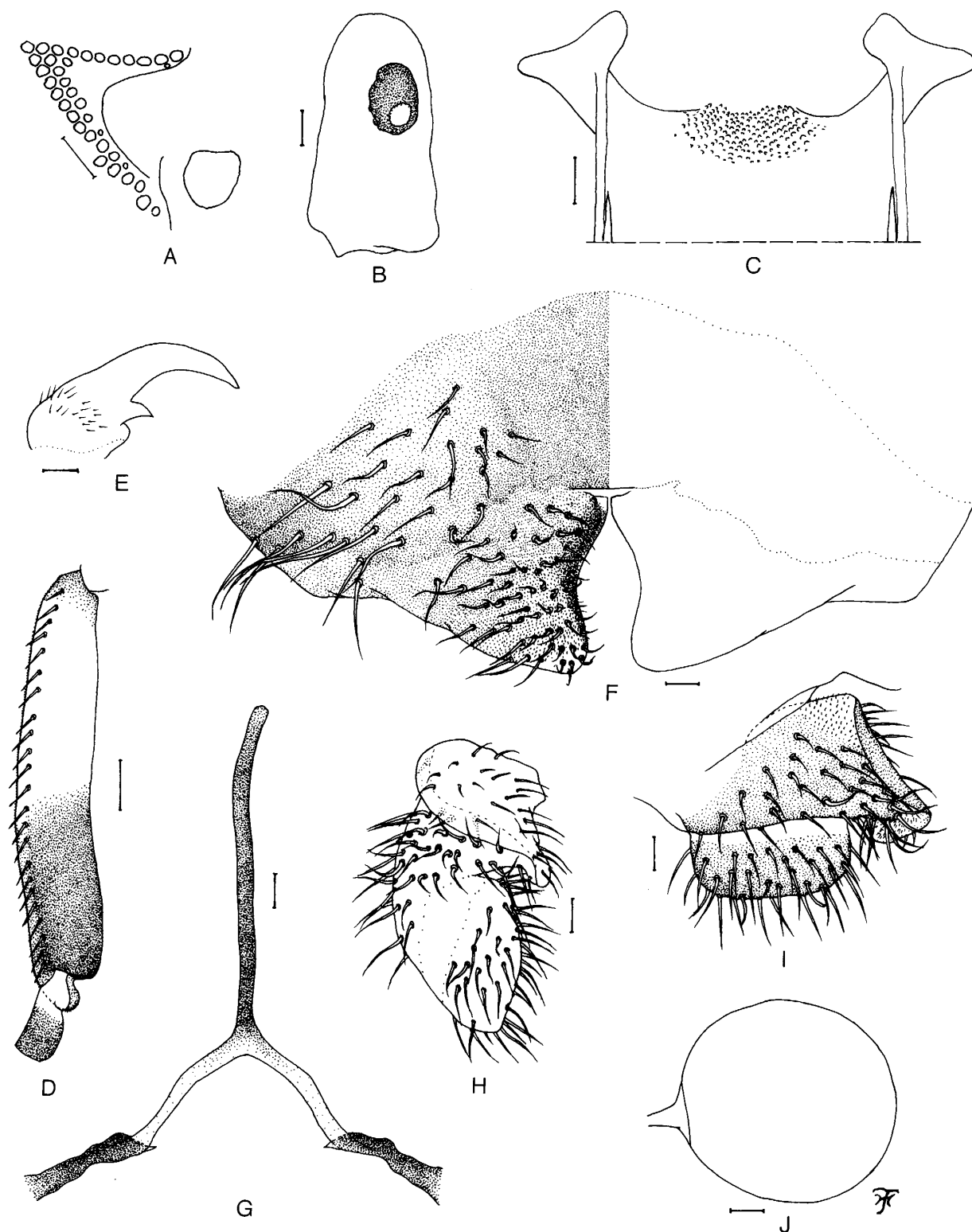


Fig. 1. Female of *Simulium* (*Simulium*) *forcipatum*. A, fronto-ocular area (right side); B, 3rd segment of maxillary palp with sensory vesicle (right side; front view); C, cibarium; D, basitarsus and 2nd tarsal segment of hind leg showing calcipala and pedisulcus (left side; outer view); E, claw; F, 8th sternite and ovipositor valves *in situ* (ventral view); G, genital fork (ventral view); H and I, paraprocts showing anteroventral plate and cerci *in situ* (right side; H, ventral view; I, lateral view); J, spermatheca. Scale bars. 0.1 mm for D; 0.05 mm for A; 0.02 mm for B, C and F-J; 0.01 mm for E.

Boyyo). Fronto-ocular area (Fig. 1A) well developed, directed laterally and a little upwardly. Clypeus brownish-black, slightly shiny, whitish-gray pruinose, moderately covered with dark stout hairs except median area widely bare or very sparsely haired longitudinally; clypeus silvery iridescent when illuminated at certain angle of light. Labrum 0.62–0.66 times as long as clypeus (0.58 times in 1 female from Bayyo). Antenna composed of 2+9 segments, medium brown except scape and pedicel dark yellow when viewed posteriorly but base of 1st flagellar segment also dark yellow when viewed anteriorly. Maxillary palp medium brown, composed of 5 segments, proportional lengths of 3rd, 4th, and 5th segments 1.00 : 1.13–1.18 : 2.26–2.58 (1.00 : 1.07 : 2.07 in 1 female from Bayyo); 3rd segment (Fig. 1B) slightly enlarged; sensory vesicle (Fig. 1B) of medium-size, ellipsoidal, 0.27–0.32 (0.25 in 1 female from Bayyo) times as long as 3rd segment, with medium-sized round opening subapically. Maxillary lacinia with 13–15 inner and 15 outer teeth (16 inner and 15 or 16 outer teeth in 1 female from Bayyo). Mandible with 34 inner and 15 outer teeth (32–37 inner and 14 outer teeth in 1 female from Bayyo). Cibarium (Fig. 1C) with about 160 minute tubercles. **Thorax.** Scutum black, shiny, not patterned, white pruinose when illuminated at certain angle of light, moderately covered with light to dark brown recumbent short hairs interspersed with dark brown long upright hairs on prescutellar area. Scutellum dark brown to brownish-black, shiny, with dark brown long upright hairs. Postnotum dark brown to brownish-black, shiny, white pruinose when illuminated at certain angle of light and bare. Pleural membrane bare. Katepisternum longer than deep, brownish-black, bare, shiny when illuminated. **Legs.** Medium brown to brownish-black except basal 1/4 of mid basitarsus dark yellow to light brown, basal 1/2 of hind basitarsus yellowish-white (except base darkened) and a little less than basal 1/2 of hind 2nd tarsal segment dark yellow; all tibiae with silvery sheen on outer surface (fore tibia) or on posterior surface (mid and hind tibiae) when illuminated at certain angle of light. Fore tarsus with thick dorsal hair crest; basitarsus moderately dilated, 5.2 times as long as its greatest width. Hind basitarsus (Fig. 1D) nearly parallel-sided, 5.46 times as long as its greatest width, 0.73 and 0.71 times as wide as

greatest widths of hind tibia and femur, respectively; calcipala slightly shorter than width at base, and 0.48 times as wide as width of basitarsus; pedisulcus distinct. Claw (Fig. 1E) with small subbasal tooth, and furnished with several minute setae near base. **Wing.** Length 3.0 mm (3.3 mm in 3 females from Bayyo). Costa with spinules and hairs. Subcosta haired except near apex bare. Basal section of vein R bare; R₁ with spinules and hairs; R₂ with hairs only. Hairs at base of stem vein dark brown. Basal cell absent. **Abdomen.** Basal scale brownish-black, with fringe of long hairs. Dorsal surface of abdominal segments dark brown to brownish-black, with dark hairs; 2nd segment with pair of large silvery iridescent dorsolateral spots broadly connected to each other medially; tergites 5–9 shiny. Ventral surface of abdominal segment 7 with large sternal plate posteromedially. **Genitalia.** Sternite 8 (Fig. 1F) well sclerotized, moderately depressed medially, moderately covered with short to long hairs on each side; ovipositor valves (Fig. 1F) nearly triangular, with round posteromedial tip, membranous except narrow area along inner margin strongly sclerotized, moderately covered with short to long hairs as well as microsetae except posteromedial tip narrowly bare; inner margins moderately concave and moderately separated from each other. Genital fork (Fig. 1G) of inverted-Y form; stem slender and well sclerotized; arms slender, each with strongly-sclerotized lateral ridge. Paraproct in ventral view (Fig. 1H) with broad moderately-sclerotized anteroventral plate having about 20 short hairs scattered on its round surface; paraproct in lateral view (Fig. 1I) somewhat produced ventroposteriorly beyond ventral margin of cercus, moderately covered with short to long hairs on lateral surface; anteroventral plate 0.62 times as long as greatest width of paraproct. Cercus in lateral view (Fig. 1I) nearly rectangular, about 2.3 times as wide as long and covered with many short to long hairs. Spermatheca (Fig. 1J) globular, well sclerotized except duct and small area of junction to duct unsclerotized, without reticulate surface patterns; minute internal setae present; both accessory ducts subequal in diameter to each other, and also to that of main duct.

Male. Body length 3.5 mm (3.8 mm in 3 males from Bayyo). **Head.** As wide as thorax. Upper eye consisting of large facets in 23 or 24 vertical columns and in 25 horizontal rows (in

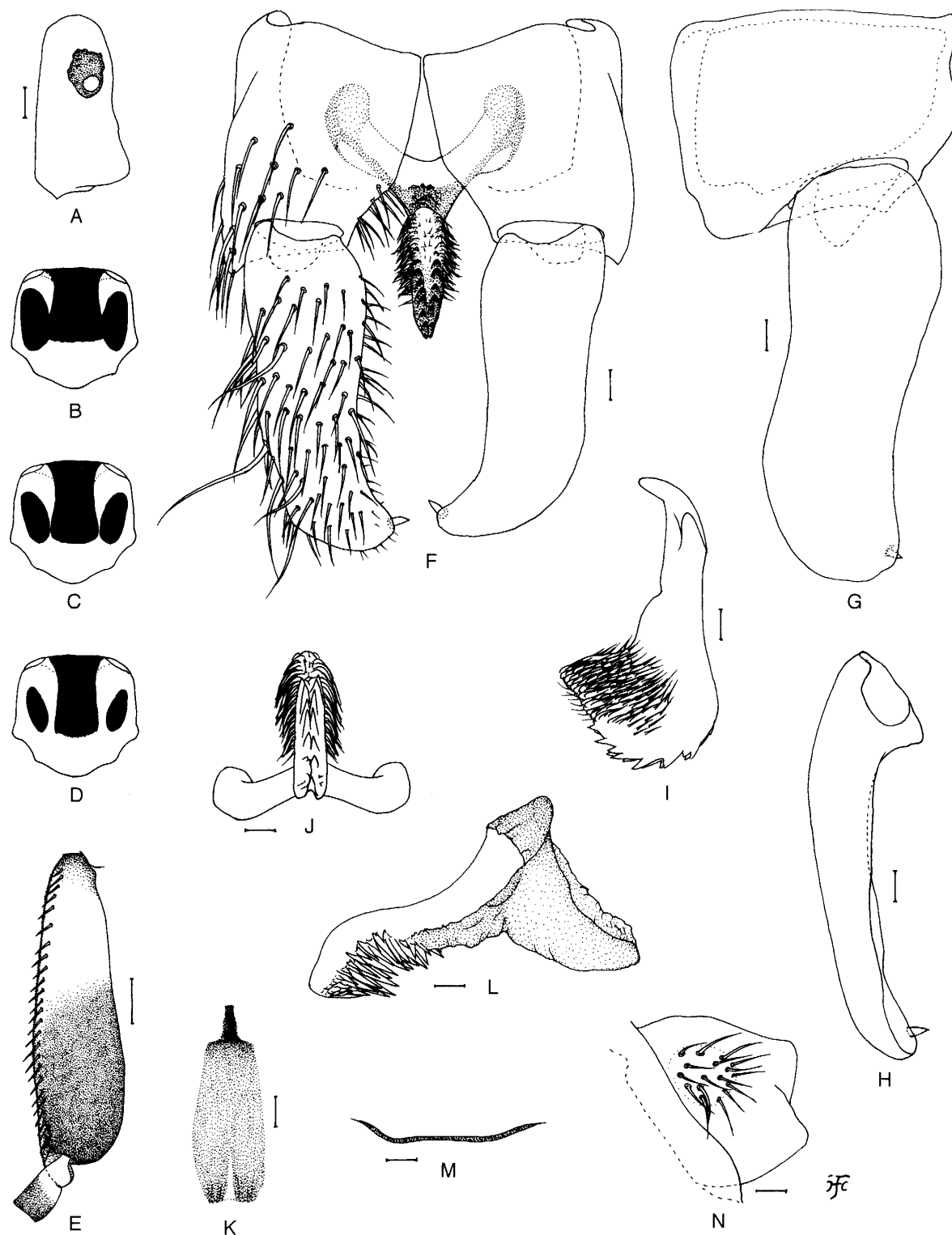


Fig. 2. Male of *Simulium* (*Simulium*) *forcipatum*. A, 3rd segment of maxillary palp with sensory vesicle (right side; front view); B-D, scuta showing 3 different patterns of markings (dorsal view); E, basitarsus and 2nd tarsal segment of hind leg showing calcipala and pedisulcus (left side; outer view); F, coxites, styles and ventral plate *in situ* (ventral view); G, coxite and style *in situ* (right side; ventrolateral view); H, style (left side; dorsolateral view); I and J, ventral plates (I, lateral view; J, end view); K, median sclerite (end view); L, paramere (left side; lateral view); M, dorsal plate (ventroposterior view); N, cercus (right side; lateral view). Scale bars. 0.1 mm for E; 0.02 mm for A and F-N.

19 or 20 vertical columns and 22 or 23 horizontal rows in 3 males from Bayyo, in 19 vertical columns and 21 horizontal rows in 1 male from Banaue, and in 19 vertical columns and 19 or 20 horizontal rows in 2 pharate males from Los Baños). Clypeus dark brown to brownish-black, whitish-gray pruinose, silvery iridescent when illuminated at certain angle of light, moderately covered with dark brown long hairs. Antenna composed of 2+9 segments, medium brown except scape and pedicel light brown, and base of 1st flagellar segment yellow; 1st flagellar segment elongated, about 1.5 times as long as 2nd one. Maxillary palp composed of 5 segments, proportional lengths of 3rd, 4th, and 5th segments 1.0 : 1.4 : 3.1; 3rd segment (Fig. 2A) of normal size; sensory vesicle ellipsoidal, 0.27 times as long as 3rd segment and with medium-sized opening near apex. **Thorax.** Scutum black, with distinct pattern of silvery iridescent markings as shown in Fig. 2B (scutal patterns in 2 males from Bayyo are as in Fig. 2C, and those of both 1 male from Bayyo and 1 male from Banaue are as in Fig. 2D), and densely covered with copper-colored short hairs intermixed with dark brown short hairs on anterior surface near anterior margin and dark brown long upright hairs on prescutellar area. Scutellum brownish-black, with dark brown long upright hairs. Postnotum brownish-black, white pruinose when illuminated at certain angle of light, and bare. Pleural membrane and katepisternum similar to those of female. **Legs.** Medium brown to brownish-black except basal 2/5 of hind basitarsus and basal 1/2 of hind 2nd tarsal segment yellowish-white; fore tibia silvery sheeny on outer surface, mid tibia silvery sheeny on posterior surface when illuminated at certain angle of light. Fore tarsus with thick dorsal hair crest; basitarsus moderately dilated, 5.6 times as long as its greatest width. Hind basitarsus (Fig. 2E) enlarged, wedge-shaped, 3.58 times as long as its greatest width, 0.84 and 0.97 times as wide as greatest widths of hind tibia and femur, respectively; calcipala small, nearly as long as its basal width, and 0.32 times as wide as greatest width of basitarsus; pedisulcus distinct. **Wing.** Length 2.6 mm (3.1 mm in 3 males from Bayyo). Other characters as in female except subcosta entirely bare. **Abdomen.** Basal scale brownish-black, with fringe of long hairs. Dorsal surface of abdomen dark brown to brownish-black, with

dark hairs; segments 2 and 4–8 each with pair of silvery iridescent dorsolateral spots, broadly connected in middle to each other on segment 2, narrowly connected in middle on segments 4 and 5 and not connected on segments 6–8. **Genitalia.** Coxite in ventral view (Fig. 2F) nearly quadrate. Style in ventral view (Fig. 2F) elongated, longer than coxite, nearly parallel-sided on basal 1/2, then somewhat narrowed toward apex, and with stout apical spine; style in ventrolateral view (Fig. 2G) gently sinuous, nearly parallel-sided, 2.7 times as long as greatest breadth near base and with round apex; style in dorsolateral view (Fig. 2H) flattened dorsoventrally, with small basal protuberance having no spine. Ventral plate in ventral view (Fig. 2F) of Y-shaped; body narrow and compressed, having ventrally-produced median process covered with stout setae on both lateral surfaces, a few minute setae on anterior surface and several minute setae on anterior 1/2 of ventral surface; posterior surface and posterior 1/2 of posteroventral surface with several teeth in vertical rows lying very close; basal arms stout and diverged basally from each other at right angle; ventral plate in lateral view (Fig. 2I) with body and its ventrally-produced process with round posterior margin having sharp teeth; ventral plate in end view (Fig. 2J) with body and its ventrally-produced median process nearly parallel-sided, with several teeth in vertical rows lying very close sublaterally. Median sclerite (Fig. 2K) wide, thin, plate-like, with median portion deeply unsclerotized. Paramere (Fig. 2L) wide basally and with several parameral hooks apically. Aedeagal membrane moderately covered with minute setae, with small moderately sclerotized dorsal plate (Fig. 2M). Ventral surface of 10th abdominal segment without any distinct hairs. Cercus (Fig. 2N) rounded, with 14–17 distinct hairs (12–15 hairs in males from Bayyo).

Pupa. Body length (excluding gill filaments) 3.2–3.8 mm (4.2–4.5 mm in pupae from Bayyo and Sumigor). **Head.** Integument (Fig. 3A) dark yellow to yellowish-brown, bare: frons with 2 simple long trichomes close to each other on each side; face with 1 simple long trichome on each side. **Thorax.** Integument (Fig. 3B) yellow to yellowish-brown, moderately covered with round and cone-shaped tubercles except anterior portion including wide area around base of gill bare though narrow

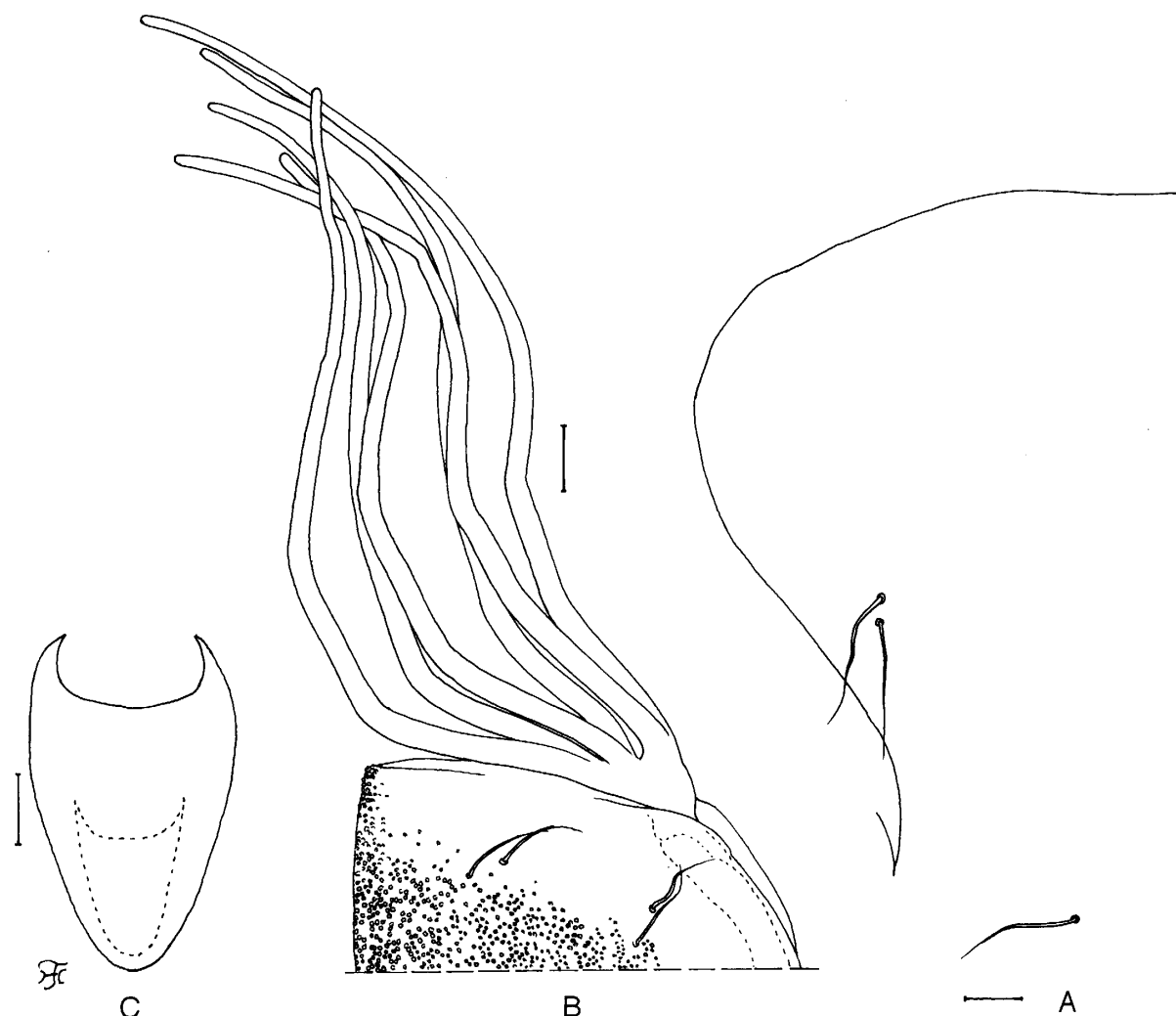


Fig. 3. Pupa of *Simulium* (*Simulium*) *forcipatum*. A, frons and portion of face (right half); B, gill filaments and anterior 2/3 of thoracic integument (right side; dorsal view), C, cocoon (dorsal view). Scale bars. 1.0 mm for C; 0.1 mm for A and B.

median longitudinal portion with tubercles even anteriorly; thorax with 2 simple very long trichomes anterodorsally, 2 simple very long trichomes anterolaterally, 1 simple long trichome posterolaterally and 3 simple trichomes (2 very long, 1 long) ventrolaterally on each side. Gill (Fig. 3B) with 6 slender thread-like filaments arranged in pairs lying nearly horizontally or obliquely; inner and outer pairs very short-stalked while middle pair very short-stalked or almost sessile; all filaments yellowish-brown, subequal in length (length differs from 1.3 to 1.8 mm by individual pupae) (1.5 to 2.4 mm in pupae from Bayyo) and thickness (though outer paired filaments very slightly thicker than others in some pupae), gradually tapered toward apex though basal 1/3 of filaments of almost same width in some pupae; innermost and outermost filaments

spreading basally at angle of 40–90 degrees; cuticular surface with distinct annular ridges and furrows throughout their length, covered with minute tubercles of different sizes, relatively larger ones on ridges and smaller ones on interridge spaces. **Abdomen.** Dorsally, segment 1 yellowish-brown and segments 2–9 almost transparent; segment 1 moderately and neatly covered with minute tubercles on posterior 1/4 though medial portion bare in some pupae, and with 1 simple slender medium-long hair-like seta on each side; segment 2 with 1 simple slender medium-long hair-like seta, 1 simple short spinous seta and 4 simple hooked spines on each side; segments 3 and 4 each with 4 simple hooked spines (much larger than those on segment 2) and 1 simple short spinous seta on each side; segments 5–9 covered with comb-like groups of minute spines; segment 8

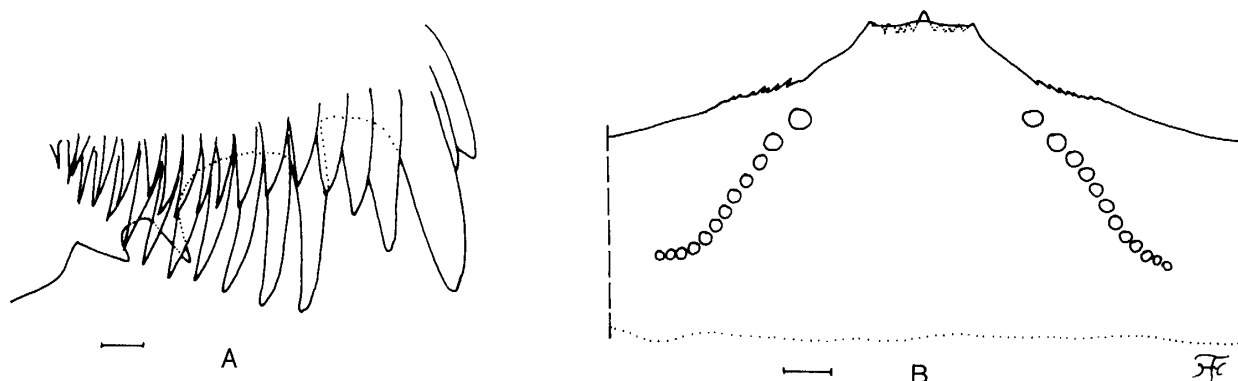


Fig. 4. Mature larva of *Simulium* (*Simulium*) *forcipatum*. A, mandible; B, hypostoma. Scale bars. 0.03 mm for B; 0.01 mm for A.

with transverse row of spine-combs directed posteriorly on each side; terminal hook absent. Ventrally, all segments transparent; segments 4–8 each with comb-like groups of minute spines on each side; segment 4 with a few simple short setae on each side; segment 5 with pair of simple hooks submedially and 1 simple short seta on each side; segments 6 and 7 each with pair of simple inner and outer hooks widely spaced and 1 simple short seta on each side. Grapnel-like hooklets absent. **Cocoon** (Fig. 3C). Wall-pocket-shaped, moderately woven with a few to many small open spaces near opening, somewhat extending ventrolaterally, and nearly transparent to ochreous; posterior 1/2 with many small granules on outer surface, then appearing rugose; 4.0–5.0 mm long by 1.8–2.5 mm wide.

Mature larva. Body length 7.4–9.8 mm. Body color gray to grayish-brown. Abdomen (Fig. 9A, B) slightly becoming wider from segment 1 to segment 5, then abruptly widened on segment 6, widest on segment 7, then narrowed on segment 8, and narrow on segment 9 when viewed dorsally. Cephalic apotome (Fig. 9C–E) entirely yellow to light or medium brown, with medium to dark brown vertical band of various lengths along each lateral margin and medium to dark brown narrow transverse band medially along posterior margin; head spots light to medium brown except posterior spots of posterolateral spots less distinct in some larvae, and posterior spots of mediolateral spots usually medium brown; mediolateral spots usually connected to anterior spot of posterolateral spots by slightly to moderately darkened band; posterior spots of mediolongitudinal spots usually connected to medium to dark brown transverse band along

posterior margin. Lateral surface of head capsule medium brown except eye-spot region narrowly white-yellow, eyebrow and narrow to wide area along anterior margin and/or below eye-spot region yellow; 3 isolated spots below eye-spot region all yellow or 1 or 2 spots light to medium brown. Ventral surface of head capsule (Fig. 9G) medium to dark brown except hypostoma and transverse band of various widths along posterior margin of hypostoma yellow; transverse band on each side of postgenal cleft light to dark brown, usually well defined by yellow surrounding line. Cervical sclerite composed of 2 yellow small elliptical pieces, not fused to occiput which extends medially, very widely separated medially from each other. Antenna composed of 3 segments and apical sensillum, slightly longer than stem of labral fan; proportional lengths of 1st, 2nd, and 3rd segments 1.00 : 1.43–1.54 : 0.67–0.75. Labral fan with 50–56 main rays. Mandible (Fig. 4A) with mandibular serrations composed of 2 stout teeth; major and longer tooth at obtuse angle to mandible on apical side; supernumerary serrations absent; comb-teeth decreasing in length from 1st to 3rd. Hypostoma (Fig. 4B) with 9 anterior teeth, median tooth most prominent, outer and inner teeth of 3 intermediate teeth subequal in length to corner teeth, and middle tooth of 3 intermediate teeth smallest; lateral margins weakly serrate subapically; 11–13 hypostomal bristles widely diverging posteriorly from lateral border on each side. Postgenal cleft (Fig. 9G) medium-long, bullet-shaped, rounded apically, 2.1–2.3 times as long as postgenal bridge. Thoracic cuticle almost bare. Abdominal cuticle almost bare except each side of anal sclerite moderately covered with short colorless setae. Rectal

scales composed of numerous dark comb-like minute spines. Rectal organ of compound lobes, each with 18–26 finger-like secondary lobules. Anal sclerite X-shaped, with broadened anterior arms about 0.6 times as long as posterior ones, with wide thinly-sclerotized extension between anterior arms and small triangular thinly-sclerotized extension posterior to basal juncture area; 2 or 3 sensilla on basal juncture area and 11 or 12 sensilla posterior to posterior arms. Last abdominal segment somewhat bulged laterally, lacking ventral papillae. Posterior circlet with 216–220 rows of hooklets with up to 30 hooklets per row.

SPECIMENS EXAMINED. 2 females, 1 male (all with their associated pupal exuviae and cocoons), reared from pupae, 1 pupa and 2 mature larvae, collected from a river (width about 20 m, water temperature 18°C, exposed to sun, altitude 920 m) near the junction to Barlig from the road between Banaue and Bontoc, Magkang, Mountain Province, Luzon Island, Philippines, 14.II.2005, by H. Takaoka; 2 females (each with its associated pupal exuviae and cocoon), 2 pupae and 1 mature larva, collected from Ab-ab River (width 20–30 m, water temperature 17°C, exposed to sun, altitude 1,180 m) crossing the road from Banaue to Magkang, Talubin, Mountain Province, 14.II.2005, by H. Takaoka; 3 females, 3 males (all with their associated pupal exuviae and cocoons), 10 pupae and 4 mature larvae, collected from a stream (width 1–3 m, water temperature 15°C, exposed to sun, altitude 1,400 m) crossing the road from Banaue to Magkang, Bayyo, Mountain Province, 14.II.2005, by H. Takaoka; 1 pupa collected from a tributary (width 0.5–3.0 m, water temperature 15.0°C, shaded, altitude 1,680 m) of the stream flowing down below Sumigor Bridge (the road between Banaue and Bontoc), west of Banaue Town, Ifugao Province, 15.II.2005, by H. Takaoka; 1 male (with its associated pupal exuviae and cocoon), collected from a river (width 5–8 m, water temperature 14.5°C, exposed to sun, altitude 1,690 m) flowing down in the rice terrace, near Tribe Resort, Banaue,

Ifugao Province, 16.II.2005, by H. Takaoka; 2 pharate males, 15 pupae, 3 pupal exuviae and 3 mature larvae, all collected from rapids of Molawin Creek (width 0.5–2.0 m, water temperature 23.2°C, partially shaded, altitude 192 m), at Flat Rocks, Los Baños, Laguna Province, 22.IX.2006, by H. Takaoka.

ECOLOGICAL NOTES. The pupae and larvae of this species were collected mainly from stones and also less frequently from slender grasses trailing in moderately-flowing rivers, and from stones in rapidly-flowing streams. Associated species were *S. (Gomphostilbia) bansonae* Takaoka, *S. (Wallacellum) cabrerai* Takaoka, *S. (W.) recurvum* Takaoka, *S. (W.) spinosibranchium* Takaoka, *S. (S.)* sp. (probably *simulacrum* Delfinado), *S. (S.) aquilum* sp. nov., *S. (S.) conspicuum* sp. nov. and *S. (S.) sumigorense* sp. nov.

REMARKS. *Simulium* (S.) *forcipatum* Delfinado was originally described from an adult male collected from Abatan, Mountain Province in Luzon Island (Delfinado, 1969), and has been classified to the *melanopus* species-group within the subgenus *Simulium* s. str. (Crosskey and Howard, 1997; Takaoka, 2003). In this study, the female, pupal and larval specimens of this species were obtained for the first time. The identification of the male reared from the pupa collected at Magkang was easily made by the unique shape of the ventral plate (Fig. 2F) as well as the ordinary scutal pattern of color markings (Fig. 2B), similar to those illustrated from the holotype specimen (Takaoka, 1983). All the males reared from the pupae collected from Bayyo and Banaue were tentatively identified as *S. (S.) forcipatum* mainly based on the shape of the ventral plate, as well as characters of their pupal exuviae. However, it is noteworthy that they seem to be different from the male from Magkang by the scutal patterns (Fig. 2C, D) and the large eye-facets in 19 or 20 vertical columns and 21–23 horizontal

rows. These differences, though regarded as an intraspecific variation in this study, might be an indication that *S. (S.) forcipatum* is a species-complex composed of two or more sibling species.

The female of this species is almost indistinguishable from that of *S. (S.) atrum* Delfinado described from the adult females collected from Mt. Katanglad, Bukidnon, Mindanao Island (Delfinado, 1969), and there is a possibility that *S. (S.) forcipatum* and *S. (S.) atrum* belong to the same species. If so, *S. (S.) forcipatum* should be synonymised with *S. (S.) atrum*. However, such a conclusion can not be drawn until adult males of *S. (S.) atrum* reared from the pupae collected from the type locality in Mindanao Island are available. It is because there are at least three other related species which are very similar in the adult stage but are distinguished from one another by the pupal characteristics, as shown hereafter.

Simulium (Simulium) aquilum sp. nov.

DESCRIPTION. Female. Body length 3.0 mm. **Head.** Nearly as in female of *S. (S.) forcipatum* except following characters: Frontal ratio 1.34:1.00:1.20; frons-head ratio 1.0:3.8. Clypeus moderately covered with dark stout hairs except narrow portion near upper margin bare. Labrum 0.58 times as long as clypeus. Antenna dark brown except scape, base of pedicel, and base of 1st flagellar segment yellow, and most of pedicel dark yellow to yellowish-brown. Maxillary palp medium brown, composed of 5 segments, proportional lengths of 3rd, 4th, and 5th segments 1.00:1.05:2.03; 3rd segment slightly enlarged; sensory vesicle (Fig. 5A) of medium-size, ellipsoidal, 0.32 times as long as 3rd segment, with large round opening apically. Maxillary lacinia with 13 or 14 inner and 17 outer teeth. Mandible with 34 or 35 inner and 19 or 20 outer teeth. **Thorax.** As in female of *S. (S.) forcipatum*. **Legs.** Color nearly as in female of *S. (S.) forcipatum* except mid basitarsus dark yellow to light brown only basally and hind basitarsus yellowish-white on a little more than basal 1/2 (except base darkened) and hind 2nd tarsal

segment yellowish-white on basal 1/2. Fore basitarsus moderately dilated, 4.9 times as long as its greatest width. Hind basitarsus nearly parallel-sided, 5.21 times as long as its greatest width, 0.72 and 0.64 times as wide as greatest widths of hind tibia and femur, respectively; calcipala slightly shorter than width at base, and 0.39 times as wide as width of basitarsus; pedisulcus distinct. Claw with small subbasal tooth similar to that of *S. (S.) forcipatum*. **Wing.** Length 3.4 mm. Other characters as in female of *S. (S.) forcipatum* except basal section of vein R with a few hairs on apical 1/3 or 1/4. **Abdomen.** As in female of *S. (S.) forcipatum*. **Genitalia.** Nearly as in female of *S. (S.) forcipatum* except spermatheca ellipsoidal (Fig. 5B).

Pupa. Body length (excluding gill filaments) about 4.0 mm. **Head.** Integument (Fig. 5C) yellowish-brown, densely and neatly covered with round tubercles on entire surface: frons with 2 simple long trichomes moderately close together on each side; face with 1 simple medium-long trichome on each side. **Thorax.** Integument yellowish-brown, densely and neatly covered with round and cone-shaped tubercles except lateral portion of posterior 2/5 bare; thorax with 2 simple long trichomes anterodorsally, 2 simple long trichomes anterolaterally, 1 simple medium-long trichome posterolaterally and 3 simple trichomes (2 long, 1 medium-long) ventrolaterally on each side. Gill (Fig. 5D) with 6 slender thread-like filaments in pairs; dorsal and ventral pairs very short-stalked, while middle pair almost sessile; all filaments whitish-yellow, directed forward and upward, then even backward and curled apically, subequal in length (1.5–2.0 mm) and thickness, gradually tapered toward apex; dorsalmost and ventralmost filaments diverged basally at angle of about 80 degrees; cuticular surface with distinct annular ridges and furrows throughout their length, covered with minute tubercles of different sizes, relatively larger ones on ridges and smaller ones on interridge spaces. **Abdomen.** Nearly as in *S. (S.) forcipatum* except segment 1 light brown, and moderately covered with minute tubercles on posterior 1/4 except median portion bare or very sparsely covered with minute tubercles, and submedian and lateral areas moderately covered with minute tubercles on entire surface between anterior and posterior margins. **Cocoon** (Fig. 5E, F). Wall-pocket-shaped, mod-

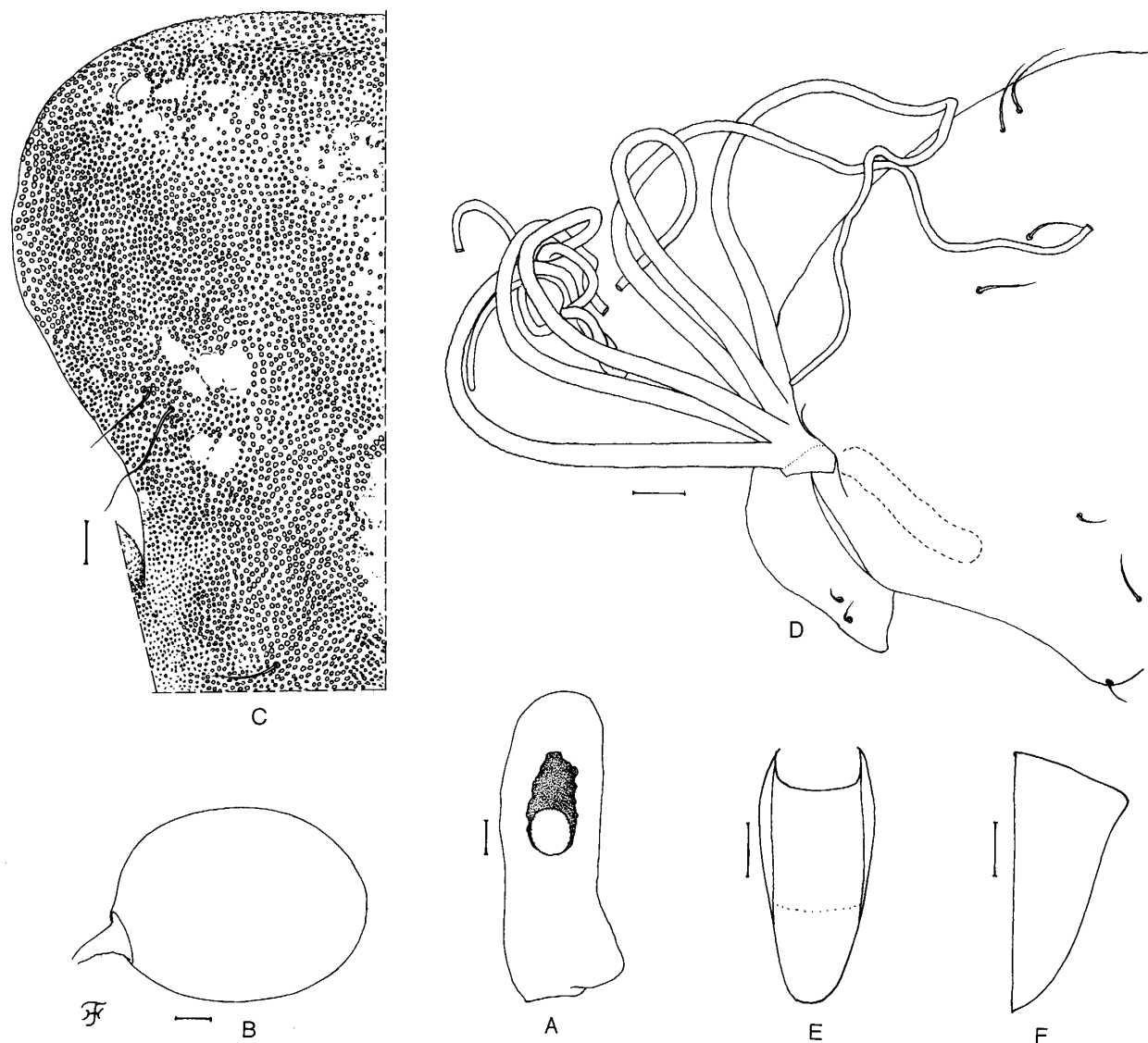


Fig. 5. Female and pupa of *Simulium* (*Simulium*) *aquilum* sp. nov. A, 3rd segment of female maxillary palp with sensory vesicle (right side; front view); B, spermatheca; C, frons and upper portion of face of pupa (right half); D, pupal gill filaments and anterior portion of thorax (tubercles omitted) (left side; outer view); E and F, cocoons (E, dorsal view; F, lateral view). Scale bars. 1.0 mm for E and F; 0.1 mm for D; 0.05 mm for C; 0.02 mm for A and B.

erately woven, with anterior margin somewhat thickly woven, with no open spaces in webs, light yellow; individual threads invisible; 4.9 mm long by 2.1 mm wide.

Male and Mature larva. Unknown.

TYPE SPECIMENS. Holotype female (with its associated pupal exuviae and cocoon), reared from a pupa collected from a tributary of the stream (width 0.5–3.0 m, water temperature 15.0°C, shaded, altitude 1,680 m) flowing down below Sumigor Bridge (the road between Banaue and Bontoc), west of Banaue Town, Ifugao

Province, Luzon Island, Philippines, 15.II. 2005, by H. Takaoka. Paratype 1 pupa, same data and date as those of the holotype.

ECOLOGICAL NOTES. The pupae of this new species were attached on the surface of stones in a fast-flowing stream. Associated species were *S. (G.) bansonae*, *S. (W.) cabrerai*, *S. (W.) spinosibranchium*, *S. (S.) conspicuum* sp. nov., *S. (S.) forcipatum* and *S. (S.) sumigorense* sp. nov.

ETYMOLOGY. The species name *aqui-*

lum refers to the dark-colored body of the female of this new species. The Latin adjective *aquilus* means dark-colored.

REMARKS. The female of *S. (S.) aquilum* sp. nov. is very similar to that of *S. (S.) forcipatum* in many features including the genitalia but is distinguished by the sensory vesicle with a large opening (Fig. 5A), the basal portion of the radial vein haired on the apical 1/3 or 1/4, and the ellipsoidal spermatheca (Fig. 5B). The pupa of *S. (S.) aquilum* sp. nov. is easily distinguished from that of *S. (S.) forcipatum* by the head densely covered with tubercles (Fig. 5C) and the cocoon without small open spaces in webs, and also without granules on the outer surface.

***Simulium (Simulium) sumigorense*
sp. nov.**

DESCRIPTION. **Male.** Body length 3.3 mm. **Head.** As wide as thorax. Upper eye consisting of large facets in 23 vertical columns and in 25 or 26 horizontal rows. Clypeus brownish-black, whitish-gray pruinose, silvery iridescent when illuminated at certain angle of light, moderately covered with dark brown long hairs except median portion widely bare longitudinally. Antenna composed of 2+9 segments, dark brown except base of 1st flagellar segment whitish-yellow; 1st flagellar segment elongated, about 1.7 times as long as 2nd one. Maxillary palp composed of 5 segments, proportional lengths of 3rd, 4th, and 5th segments 1.0:1.2:2.6; 3rd segment (Fig. 6A) of normal size; sensory vesicle ellipsoidal, 0.27 times as long as 3rd segment, and with large opening apically. **Thorax.** As in male of *S. (S.) forcipatum* with distinct pattern of silvery iridescent markings similar to that shown in Fig. 2B. **Legs.** Color as in male of *S. (S.) forcipatum*. Fore basitarsus moderately dilated, 5.8 times as long as its greatest width. Hind basitarsus enlarged, wedge-shaped, 4.08 times as long as its greatest width, 0.82 and 0.90 times as wide as greatest widths of hind tibia and femur, respectively; calcipala small, slightly shorter than its basal width, and 0.35 times as wide as greatest width of basitarsus; pedisulcus distinct. **Wing.** Length 2.9 mm. Other characters as in male of

S. (S.) forcipatum. **Abdomen.** As in male of *S. (S.) forcipatum*. **Genitalia.** Nearly as in male of *S. (S.) forcipatum* except ventral plate in ventral view (Fig. 6B) with basal arms more widely diverged basally from each other and with no minute setae on the anterior portion of the ventral surface of its ventrally-produced median process, dorsal plate weakly sclerotized, and cercus with 15 or 16 distinct hairs.

Pharate female. Only a few features were observable: Sensory vesicle, wing, tarsal claw and genitalia almost the same as those of *S. (S.) aquilum* sp. nov. except basal portion of radial vein entirely bare.

Pupa. Body length (excluding gill filaments) 3.8 mm. **Head.** As in *S. (S.) aquilum* sp. nov. except 2 simple medium-long frontal trichomes subequal in length. **Thorax.** As in *S. (S.) aquilum* sp. nov. except gill with 8 short slender thread-like filaments arranged from dorsal to ventral in (2+1)+(1+2)+2 filaments on both sides (Fig. 7A, B) in 1 male pupa or in (2+2)+2+2 filaments on right side (Fig. 7C) and in (2+1)+(1+2)+2 filaments on left side (Fig. 7D) in 1 female pupa; 2 individual filaments arising inward in female pupa while outwardly in male pupa; all pairs sessile or very short-stalked or short-stalked or with stalk of moderate length, directed forward or upward, then curled upward or backward; all filaments yellowish-white, subequal in length [1.0–1.3 mm long, though 1 filament (0.6 mm long) on right side of male pupa apparently shorter than others] and thickness, gradually tapered toward apex; dorsalmost and ventralmost filaments diverged basally at angle of about 100 degrees. **Abdomen.** Nearly as in *S. (S.) aquilum* sp. nov. except segment 1 moderately covered with minute tubercles except submedian large area on each side and narrow median area on posterior 1/4 bare. **Cocoon.** Almost the same as that of *S. (S.) aquilum* sp. nov.; 4.6 mm long by 2.0 mm wide.

Mature larva. Unknown.

TYPE SPECIMENS. Holotype male (with its associated pupal exuviae and cocoon), reared from a pupa collected from the same tributary stream where *S. (S.) aquilum* sp. nov. was collected. Paratype: 1 pharate female, same data and date as those of the holotype of *S. (S.) aquilum* sp. nov.

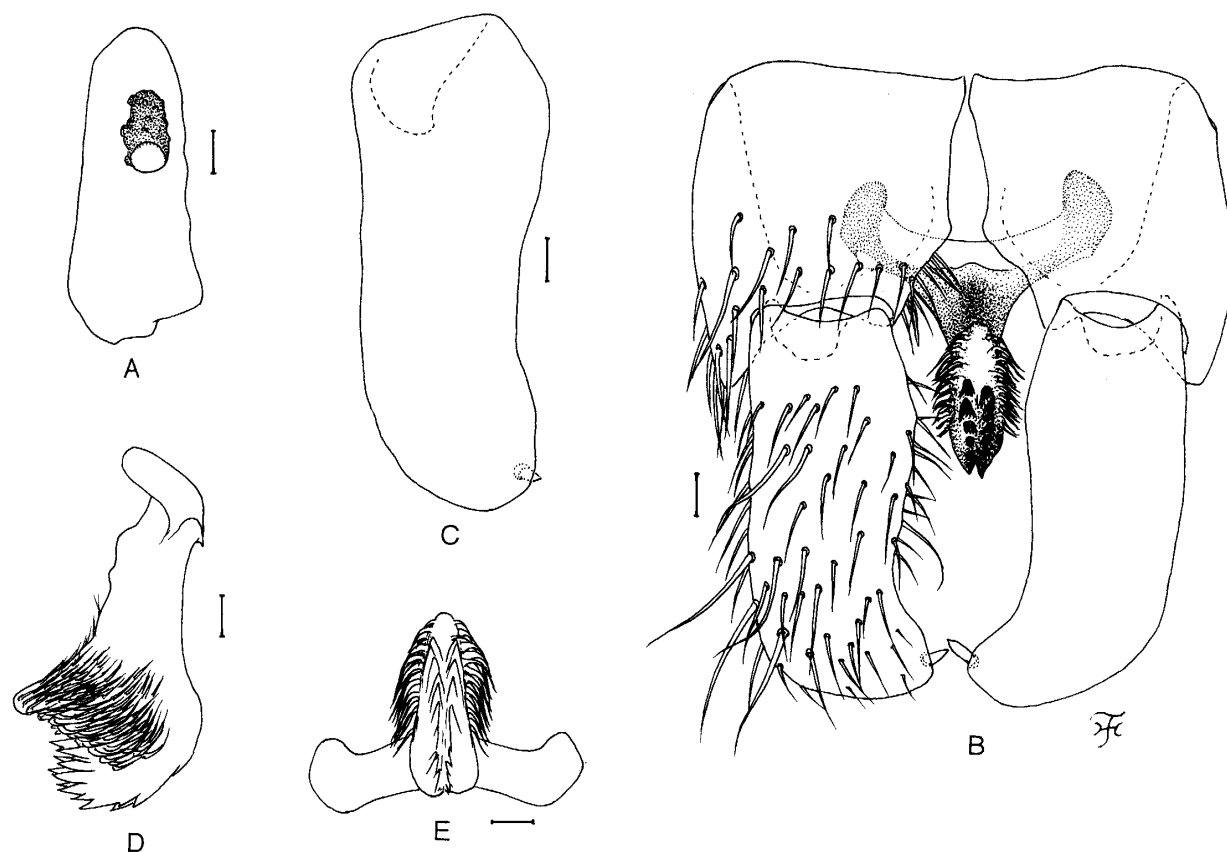


Fig. 6. Male of *Simulium* (*Simulium*) *sumigorense* sp. nov. A, 3rd segment of maxillary palp with sensory vesicle (right side; front view); B, coxites, styles and ventral plate *in situ* (ventral view); C, style (right side; ventrolateral view); D and E, ventral plates (D, lateral view; E, end view). Scale bars. 0.02 mm for A-E.

ECOLOGICAL NOTES. Almost the same as those of *S. (S.) aquilum* sp. nov.

ETYMOLOGY. The species name *sumigorense* refers to the type locality, Sumigor, where this new species was collected.

REMARKS. Apart from the difference in the number of gill filaments, the pupa of *S. (S.) sumigorense* sp. nov. is morphologically very similar to that of *S. (S.) aquilum* sp. nov. found from the same stream. It is a possibility that the difference in the pupal gill filaments is an expression of the intraspecific variation, though such cases occur very rarely, and thus these two species are conspecific to each other. However, the difference in the pupal gill filaments is regarded to be interspecific in this study since there were no pupae with intermediate combinations of the right and left gill filaments (e. g., 6+7

or 7+6, 7+7, 7+8 or 8+7, and 6+8 or 8+6 filaments). The species status of *S. (S.) sumigorense* sp. nov. appears to be also supported by the fact that the pharate female of *S. (S.) sumigorense* sp. nov. is distinguished from the female of *S. (S.) aquilum* sp. nov. by the entirely bare basal portion of the radial vein, although both females appear to be very similar to each other in other characters including the sensory vesicle with a large opening.

It is remarkable that *S. (S.) sumigorense* sp. nov. is the second species having the pupal gill with eight filaments within the *melanopus* species-group, to which this new species is assigned. All but one known species of this species-group have six gill filaments per side (Takaoka, 2003).

The pupa of *S. (S.) sumigorense* sp. nov. is easily distinguished from that of *S. (S.) forcipatum* by the head densely covered with tubercles and the cocoon without

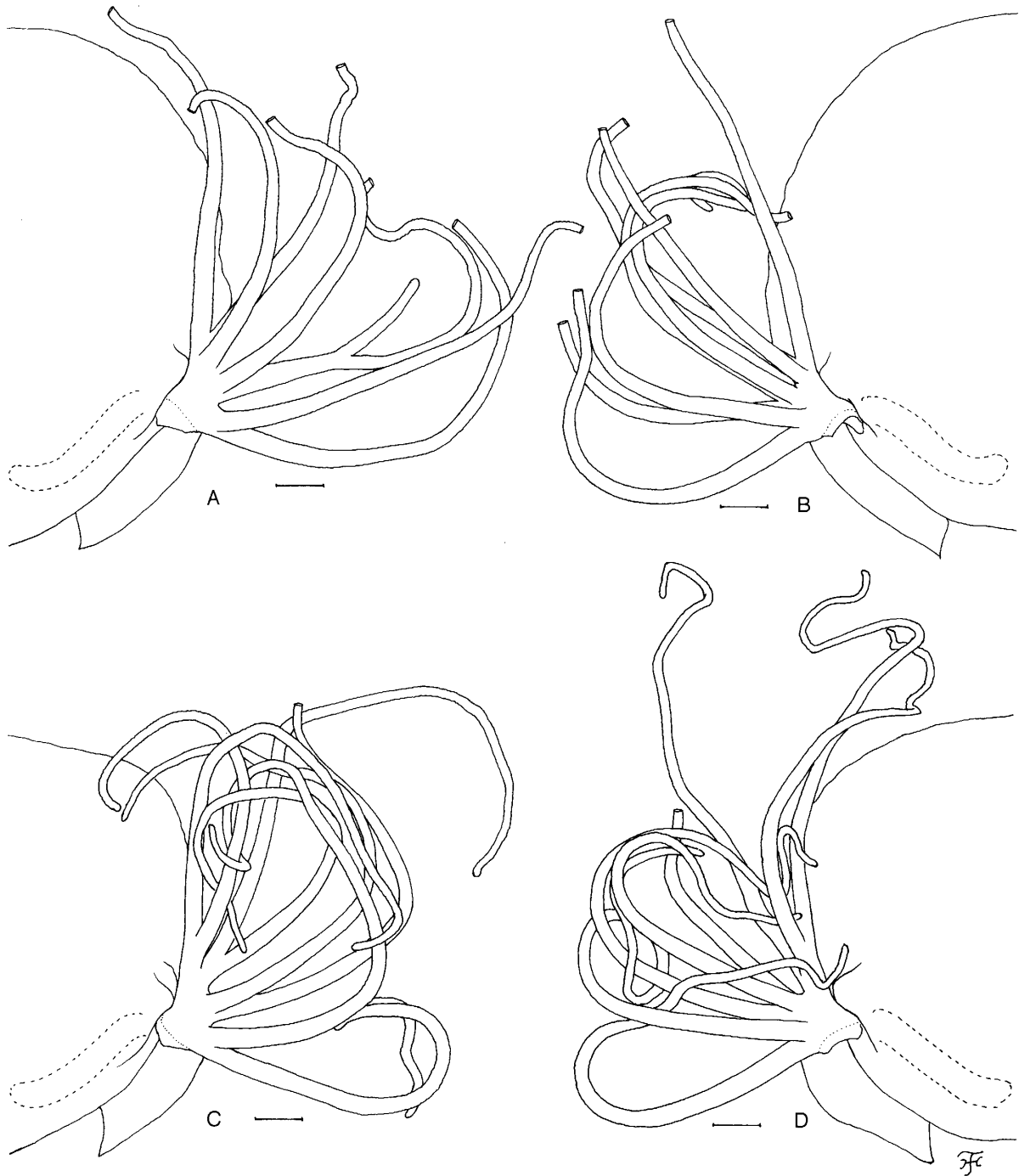


Fig. 7. Pupal gill filaments of *Simulium (Simulium) sumigorense* sp. nov. A, right side of male pupa; B, left side of male pupa; C, right side of female pupa; D, left side of female pupa. All outer view. Scale bars. 0.1 mm for A–D.

small open spaces in webs, as well as the gill with eight filaments. The male of this new species is very similar to that of *S. (S.) forcipatum*, from which it differs by the sensory vesicle with a large opening (Fig. 6A), ventral plate with basal arms widely diverged and lacking minute setae on the anterior portion of the ventral surface of

its ventrally-produced median process (Fig. 6B).

***Simulium (Simulium) conspicuum* sp. nov.**

DESCRIPTION. Female. Body length 3.4 mm. **Head.** Narrower than width of thorax. Frons brownish-black, shiny, with several dark

stout hairs along lateral margins; frontal ratio 1.26:1.00:1.21; frons-head ratio 1.0:4.3. Fronto-ocular area well developed, directed laterally. Clypeus brownish-black, slightly shiny, whitish-gray pruinose, moderately covered with dark stout hairs; clypeus silvery iridescent when illuminated at certain angle of light. Labrum 0.62 times as long as clypeus. Antenna composed of 2+9 segments, dark brown except scape entirely yellow and base of 1st flagellar segment partially yellow. Maxillary palp medium brown, composed of 5 segments, proportional lengths of 3rd, 4th, and 5th segments 1.00:1.15:2.54; 3rd segment (Fig. 8A) slightly enlarged; sensory vesicle (Fig. 8A) of medium-size, ellipsoidal, 0.31 times as long as 3rd segment, with medium-sized opening subapically. Maxillary lacinia with 12 or 13 inner and 19 outer teeth. Mandible with 32 inner and 15 outer teeth. Cibarium with about 160 minute tubercles. **Thorax.** Scutum black, shiny, not patterned, white pruinose when illuminated at certain angle of light, moderately covered with short hairs of 2 types (one type pale, slender and recumbent, the other dark brown, somewhat stout and recumbent or upright) interspersed with dark brown long upright hairs on prescutellar area. Scutellum dark brown, shiny, with dark brown long upright hairs. Postnotum dark brown, shiny, white pruinose when illuminated at certain angle of light and bare. Pleural membrane bare. Katepisternum longer than deep, dark brown, bare, shiny when illuminated. **Legs.** Color nearly as that of female of *S. (S.) forcipatum* except basal 1/4 of mid basitarsus light to medium brown. Fore tarsus with thick dorsal hair crest; basitarsus moderately dilated, 5.7 times as long as its greatest width. Hind basitarsus nearly parallel-sided, 6.71 times as long as its greatest width, 0.66 and 0.64 times as wide as greatest widths of hind tibia and femur, respectively; calcipala as long as width at base, and 0.45 times as wide as width of basitarsus; pedisulcus distinct. Claw with sub-basal tooth similar to that of female of *S. (S.) forcipatum*. **Wing.** Length 3.1 mm. Other characters as in female of *S. (S.) forcipatum*. **Abdomen.** Nearly as in female of *S. (S.) forcipatum* except ventral surface of abdominal segment 7 without definite sternal plate. **Genitalia.** Nearly as in female of *S. (S.) forcipatum* except following characters: Each arm of genital fork with strongly-sclerotized lateral ridge having

small projection anteriorly (Fig. 8C), anteroventral plate of paraproct 0.77 times as long as greatest width of paraproct, and spermatheca ellipsoidal (Fig. 8D).

Male. Body length 3.2–3.6 mm. **Head.** Width slightly narrower than thorax. Upper eye consisting of large facets in 24 vertical columns and in 26 horizontal rows. Clypeus brownish-black, whitish-gray pruinose, silvery iridescent when illuminated at certain angle of light, moderately covered with dark brown long hairs except median portion very sparsely with hairs. Antenna composed of 2+9 segments, dark brown except scape medium brown, and base of 1st flagellar segment narrowly yellow; 1st flagellar segment elongated, about 1.6 times as long as 2nd one. Maxillary palp composed of 5 segments, proportional lengths of 3rd, 4th, and 5th segments 1.0:1.2:2.3; 3rd segment (Fig. 8B) of normal size; sensory vesicle ellipsoidal, 0.22 times as long as 3rd segment and with medium-sized opening near apex. **Thorax.** Scutum black, with distinct patterns of silvery iridescent markings (2 males with pattern as shown in Fig. 8E, 1 male with pattern as shown in Fig. 8F), and moderately covered with ocherous or copper-colored short recumbent hairs interspersed with dark brown short upright hairs and also with dark brown long upright hairs on prescutellar area. Other characters as in male of *S. (S.) forcipatum*. **Legs.** Color as in male of *S. (S.) forcipatum*. Fore tarsus with thick dorsal hair crest; basitarsus moderately dilated, 5.9 times as long as its greatest width. Hind basitarsus enlarged, wedge-shaped, 4.10 times as long as its greatest width, 0.86 and 0.94 times as wide as greatest widths of hind tibia and femur, respectively; calcipala small, slightly shorter than its basal width, and 0.30 times as wide as greatest width of basitarsus; pedisulcus distinct. **Wing.** Length 3.1–3.2 mm. Other characters as in female except subcosta entirely bare. **Abdomen.** Basal scale brownish-black, with fringe of long hairs. Dorsal surface of abdomen dark brown to brownish-black, with dark hairs; segments 2 and 4–8 each with pair of silvery iridescent dorsolateral spots, broadly connected in middle to each other on segments 2 and 4–6, narrowly connected in middle on segment 7 and not connected on segment 8. **Genitalia.** Nearly as in male of *S. (S.) sumigorense* sp. nov. except cercus with 13–16 distinct hairs.

Pupa. Body length (excluding gill filaments)

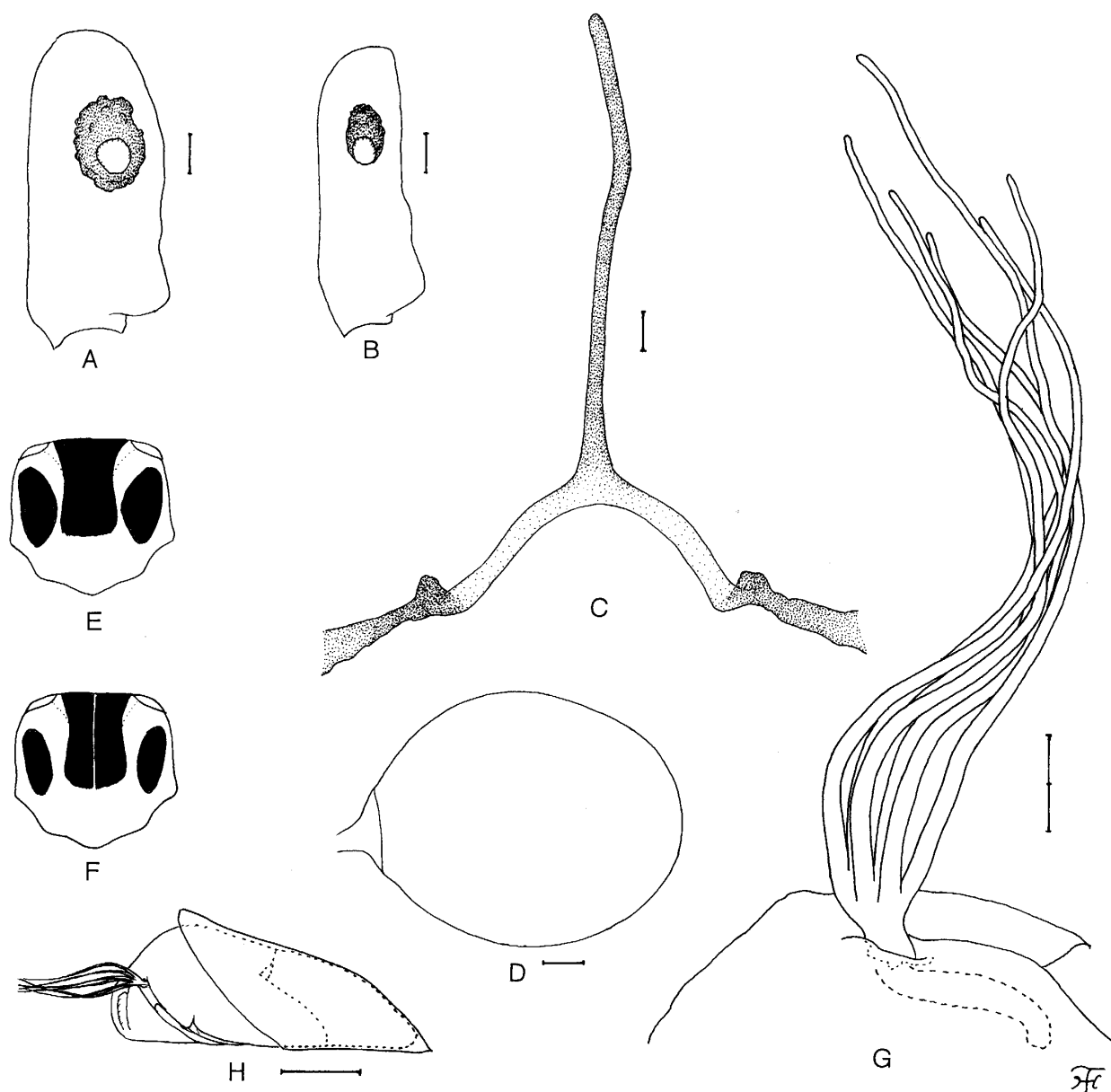


Fig. 8. Female, male and pupa of *Simulium* (*Simulium*) *conspicuum* sp. nov. A and B, 3rd segments of maxillary palp with sensory vesicle (right side; front view; A, female; B, male); C, genital fork (ventral view); D, spermatheca; E and F, male scuta; G, pupal gill filaments (right side; outer view); H, cocoon and pupa *in situ* (lateral view). Scale bars. 1.0 mm for H; 0.1 mm for G; 0.02 mm for A–D.

about 4.0 mm. **Head.** Integument dark yellow to yellowish-brown, densely covered with round tubercles except basal portion of antennal sheaths and most of lower and lateral portions of face bare: frons with 2 simple long trichomes close to each other on each side; face with 1 simple long trichome on each side. **Thorax.** Integument yellow to yellowish-brown, moderately or densely covered with round tubercles except most of lower 1/3 to 2/3 of lateral surface bare though small portion below gill base with tubercles; thorax with 2 simple very long trichomes anterodorsally, 2

simple trichomes (1 very long, 1 long) anterolaterally, 1 simple long trichome posterolaterally and 3 simple trichomes (2 long, 1 medium-long or all medium-long) ventrolaterally on each side. Gill (Fig. 8G) with 6 slender thread-like filaments arranged in pairs; dorsal pair very short-stalked while middle and ventral pairs very short-stalked or almost sessile; all filaments whitish-yellow, subequal in length (1.7–2.0 mm) and thickness, gradually tapered toward apex; innermost and outermost filaments spreading basally at angle of 40–80 degrees; cuticular surface with distinct annular

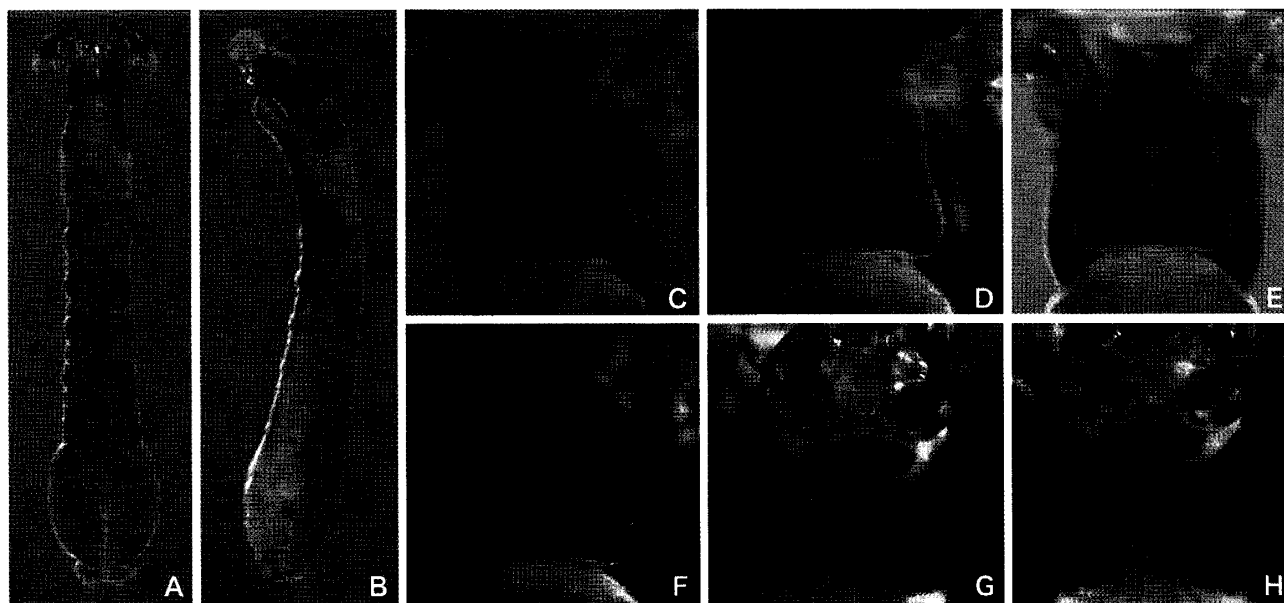


Fig. 9. Mature larvae of two species of *Simulium* (*Simulium*). A and B, whole bodies (A, dorsal view; B, lateral view); C-H, head capsules (C-F, dorsal view showing cephalic apotome; G and H, ventral view showing postgenal cleft). A, B, C-E and G, *S. (S.) forcipatum*; F and H, *S. (S.) conspicuum* sp. nov.

ridges and furrows throughout their length, covered with minute tubercles of different sizes, relatively larger ones on ridges and smaller ones on interr ridge spaces. **Abdomen.** Nearly as in *S. (S.) forcipatum* though 1st abdominal segment moderately covered with tubercles along posterior margin of dorsal surface, and dorsal surface of segment 8 with spine-combs, though lacking spine-combs in 1 pupa. **Cocoon** (Fig. 8H). Wall-pocket-shaped, thickly woven, short ventrolaterally, produced anterodorsally like eaves far beyond anterior tip of ventrolateral margins, and covering only posterior 1/2 of pupal body ventrolaterally and ventrally; individual threads invisible; outer surface with many small granules, then appearing rugose; 3.0–4.1 mm long (floor about 2.0 mm long) by 1.8 mm wide.

Mature larva. Body length 8.2–10.3 mm. Body color and shape nearly as in *S. (S.) forcipatum*. Cephalic apotome (Fig. 9F) medium to dark brown except mediolongitudinal spots and posterior spots of posterolateral spots (also narrow surrounding areas in some larvae) yellow to light brown appearing negative; mediolateral spots always medium to dark brown merged in dark background. Lateral surface of head capsule dark brown except eye-spot region whitish-yellow, eyebrow and small middle area along anterior margin yellow; all or 2 of 3 isolated spots below eye-

spot region usually yellow to light brown appearing negative. Ventral surface of head capsule (Fig. 9H) dark brown except hypostoma and narrow transverse area along posterior margin of hypostoma yellow; transverse spot on each side of postgenal cleft dark brown, usually merged into dark background or weakly to moderately defined. Cervical sclerites similar in shape to those of *S. (S.) forcipatum* but somewhat darker. Antenna composed of 3 segments and apical sensillum, very slightly longer than stem of labral fan; proportional lengths of 1st, 2nd, and 3rd segments 1.00 : 1.33–1.39 : 0.53–0.63. Labral fan with 52–56 main rays. Mandible and hypostoma as in *S. (S.) forcipatum* except hypostomal bristles 12–14 in number per side. Postgenal cleft (Fig. 9H) bullet-formed, rounded apically, 1.8–1.9 times as long as postgenal bridge. Thoracic and abdominal cuticles and rectal scales as in *S. (S.) forcipatum*. Rectal organ of compound lobes, each with 20–25 finger-like slender secondary lobules. Anal sclerite as in *S. (S.) forcipatum* except 1–3 sensilla medially on juncture area and 3–15 sensilla just posterior to posterior arms. Last abdominal segment as in *S. (S.) forcipatum*. Posterior circlet with about 230 rows of hooklets with up to 30 hooklets per row.

TYPE SPECIMENS. Holotype female

(with its associated pupal exuviae and cocoon), reared from a pupa collected from a stream (width 1–3 m, water temperature 15°C, exposed to sun, altitude 1,400 m) crossing the road from Banaue to Magkang, Bayyo, Mountain Province, Luzon Island, Philippines, 14.II.2005, by H. Takaoka. Paratype: 1 male (with its associated pupal exuviae and cocoon), 3 pupae and 3 mature larvae, same data as those of holotype; 1 male (with its associated pupal exuviae and cocoon), 2 pupae and 2 mature larvae, collected from a stream (width 0.3–1.0 m, water temperature 14.0°C, shaded, altitude 1,730 m) crossing the road between Banaue and Magkang, Mountain Province, 15. II. 2005, by H. Takaoka; 1 male (with its associated pupal exuviae and cocoon) and 2 pupae, collected from a tributary (width 0.5–3.0 m, water temperature 15.0°C, shaded, altitude 1,680 m) of the stream flowing down below Sumigor Bridge, west of Banaue Town, Ifugao Province, 15.II.2005, by H. Takaoka.

ECOLOGICAL NOTES. The pupae and larvae of this new species were collected from the surface of stones in water. Associated species were *S. (G.) bansonae*, *S. (W.) cabrerai*, *S. (W.) spinosibranchium*, *S. (S.) aquilum* sp. nov., *S. (S.) forcipatum* and *S. (S.) sumigorensis* sp. nov.

ETYMOLOGY. The species name *conspicuum* refers to the unusual shape of the cocoon of this new species. The Latin adjective *conspicuus* means unusual or remarkable.

REMARKS. *Simulium (S.) conspicuum* sp. nov. is very similar in the female to *S. (S.) forcipatum* and *S. (S.) aquilum* sp. nov. but is distinguished from these two species by having a small projection on the arms of the genital fork (Fig. 8C), also from *S. (S.) forcipatum* by the ellipsoidal spermatheca (Fig. 8D), and from *S. (S.) aquilum* sp. nov. by the medium-sized opening of the sensory vesicle (Fig. 8A) as well as the

bare basal portion of the radial vein.

In the male, *S. (S.) conspicuum* sp. nov. is very similar to *S. (S.) forcipatum* and *S. (S.) sumigorensis* but is more similar to *S. (S.) sumigorensis* sp. nov. by having the widely diverged arms of the ventral plate.

The pupa of *S. (S.) conspicuum* sp. nov. is distinctive within the *melanopus* species-group in having the wall-pocket-shaped cocoon with an eaves-like anterodorsal projection (Fig. 8H). Apart from this character, the pupa of this new species is more similar to those of *S. (S.) aquilum* sp. nov. and *S. (S.) sumigorensis* sp. nov. than that of *S. (S.) forcipatum* in that it has the head integument densely covered with tubercles.

The mature larva of this new species is very similar to that of *S. (S.) forcipatum* but is distinguished by the negative head-spot pattern (Fig. 9F).

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